EXPECTED BELT-SPECIFIC INJURY PATTERNS DEPENDENT ON THE ANGLE OF IMPACT

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ABSTRACT

Results of dummy crash test series have been studied to derive from these predictions of injury patterns related to three-point-belt usage in real road accidents. For head-on collisions correlations between injury patterns and dummy behaviour in crash tests can obviously be stated.

The aim of this paper is to discuss the influence of the angle of impact. In our dummy tests the angles varied between 20° and 56°. Two speeds of impact (v_1 = 38,5 km/h and v_2 = 47 km/h) were used. Up to 40° of impact there were no significant differences in dummy-behaviour as in head-on collisions. The same can be predicted for the belt-specific injury patterns.

INTRODUCTION

Analyses of belted passengers in road accidents show typical injury patterns. These injuries may be due to:

1. the belt itself (belt-specific injuries) and
2. the contact with parts of the compartment in spite of belt usage.

In this study, primarily belt-specific injuries should be evaluated.

From dummy crash tests, three types of motion sequences are known: (see Fig. 1 - 3)

1. stS (stiff seating)
2. soS (soft seating)
3. Sub (submarining)

Each of these types has its specific loading areas on the passenger's body. Type Sub is the classical "submarining". It is related to the type soS, in which the lap belt does not move up over the iliac crests as it is in the case of "submarining". But the biomechanical unfavourable all-over loading pattern is similar (1). The motion sequences type Sub and soS can still significantly be analysed from the injury patterns in real road accidents due to unfavourable current seat design (too soft seating) and poor belt geometry (too low lap belt angles and/or too long buckle parts) (2, 6, 8).

Fig. 4 shows high loadable body areas with favourable ranges of angles of load application. This is related to basic anatomical and mechanical knowledges and explains why the motion sequence of type stS should be the biomechanical most favourable under accident conditions (3, 7).

METHODE

Different crash conditions were used for studying the dummy behaviour dependent on the angle and speed of impact. To get similar conditions as in Sub or soS-type accidents, the dummy was seated on a commercial soft seat. The three-point belt was mounted as in a two-door car in co-driver position (off-position of the impact). The belt forces on the dummy were measured at the anchor-points A, B and C. A rearward accelerating pneumatic catapult simulated a head-on crash. The dummy was of the ALDERSON-type VIP 1030. The motion sequences of the dummy were registered by a high-speed film (250 frames per second). In Fig. 5 the test-rig under an angle of impact α is shown. The speeds of impact were v_1 = 38,5 km/h and v_2 = 47 km/h. The angles of impact varied between 20° and 56°.

The aim was to find out at what angle the dummy slipped out of the upper belt portion; in other words: when the belt force at anchor-point A decreased to zero.

RESULTS AND DISCUSSIONS

On Fig. 6, 7 and 8 the motion sequences with an angle of impact from 20, 30 and 40° are shown. There is a clear similarity to the motion sequences occuring in soS-type accidents.

Up to 40° the shoulder belt was always in the clavicula area. This is surprising but may be explained by the forward movement of the dummy arms. An increased torsion on the vertical axis of the dummy was observed which lead to an increase of forward displacement of that torso side. There was also a remarkable anteflexion of the cervical spine with lateral movements which are biomechanically unfavourable (5).

Fig. 9 shows the belt-forces on the anchor-points A, B and C versus angle of impact for the two speeds used. It can be stated that an angle of 20° does not differ from a head-on crash. Up to 40° the forces on the belts decrease at 20 - 30 percent due to the increasing rotation of the dummy torso.

Only at the angle of 56° (with v_1 = 27 km/h) the dummy torso sledged out of the shoulder belt. But even then, low restraint forces at point A could be measured because the lower arm got hooked in the upper belt loop. But in this case an excessive forward displacement of the upper torso and head occured. There is no further effect of the upper portion of the restraint system.

CONCLUSIONS

From these tests the following conclusions can be drawn:

1. For the co-driver - slipping out the shoulder belt:
   a) Up to an angle of impact of 40° similar motion sequences as in a head-on crash may be expected.
   b) The passenger loadings by the belt-system are similar and decrease at 40° only at 20 - 30%.
   c) Up to 40° belt-specific injury patterns depend more on the motion sequence type stS, soS or Sub than on the angle of impact.
   d) There is no influence of the speed of impact on the type of motion sequence.
2. For the driver - falling against the shoulder belt:
   a) Additional neck injuries due to contact to the stretched webbing may be expected.
   b) Injuries due to contact with parts of the compartment may increase because of less space for displacement available.

Generally, it can be predicted that up to an angle of ± 40° of impact belt-specific injury patterns will not differ from such of head-on crashes but additional injuries due to contact with inner parts of the compartment must be expected.

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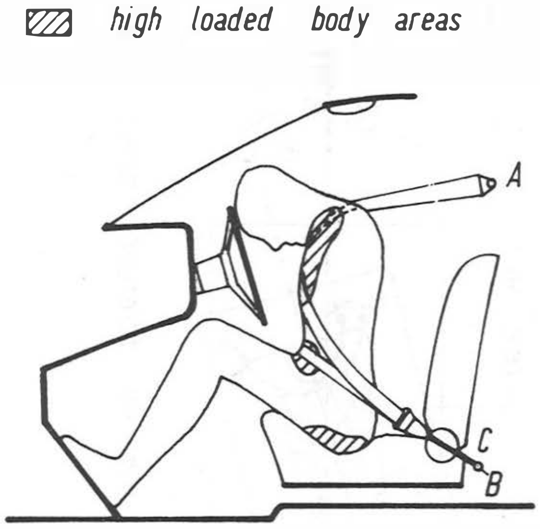

Fig. 1: Motion sequence on a stiff seating (type stS)

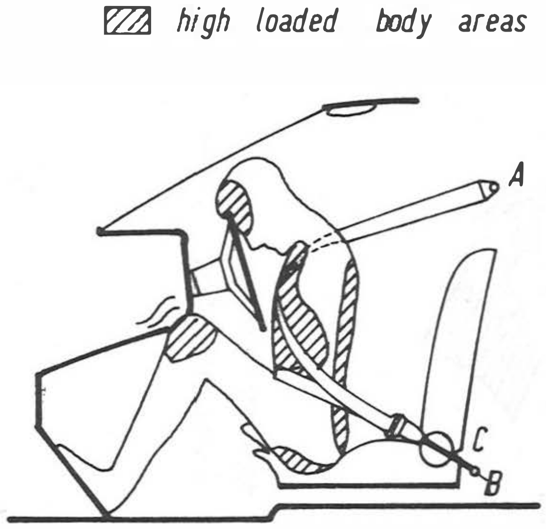

Fig. 2 : Submarining similar motion sequence (type soS)

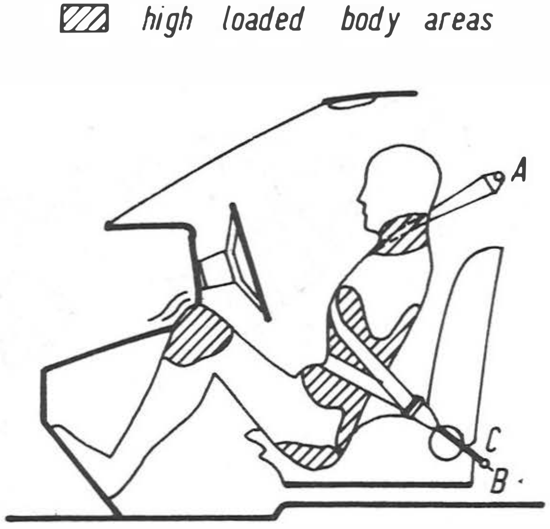

Fig. 3 : Submarining motion sequence (type Sub)

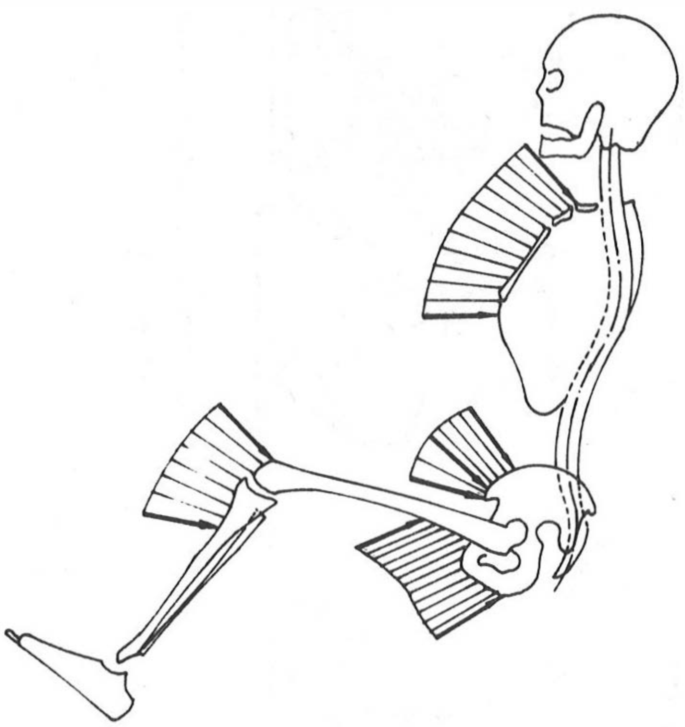

Fig. 4 : Limits of deceleration load directions on high load resistant body areas

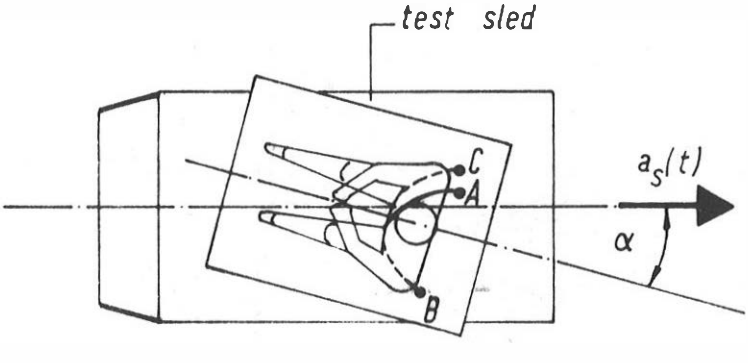

Fig. 5: Sketch of test rig for different impact angles α

Test No. 001

angle of impact

$\alpha = 20^\circ$

impact speed

$v = 38.57$ km/h

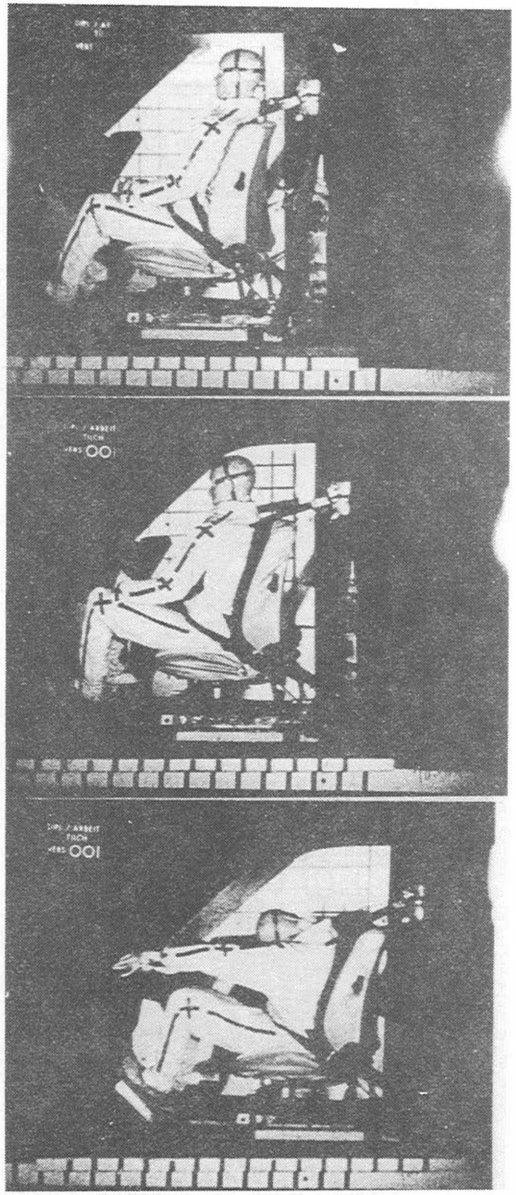

Fig. 6

Test No. 003

angle of impact

$\alpha - 30^\circ$

impact speed

$v - 37.24$ km/h

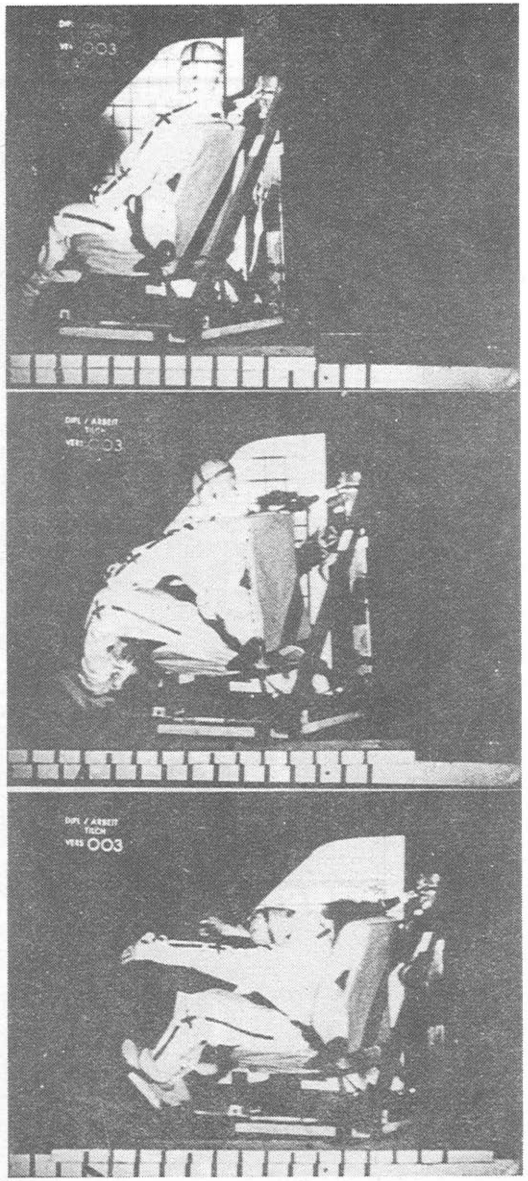

Fig. 7

Test No. 006

angle of impact

$\alpha = 40°$

impact speed

$v_1 = 36.0$ km/h

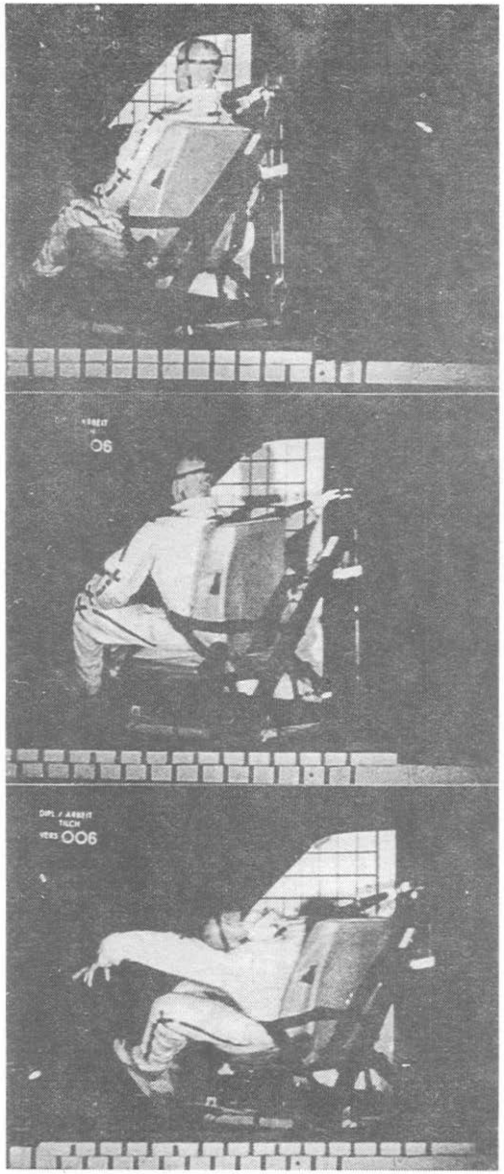

Fig. 8

Test No. 008

angle of impact

$\alpha = 56°$

impact speed

$v = 27.0$ km/h

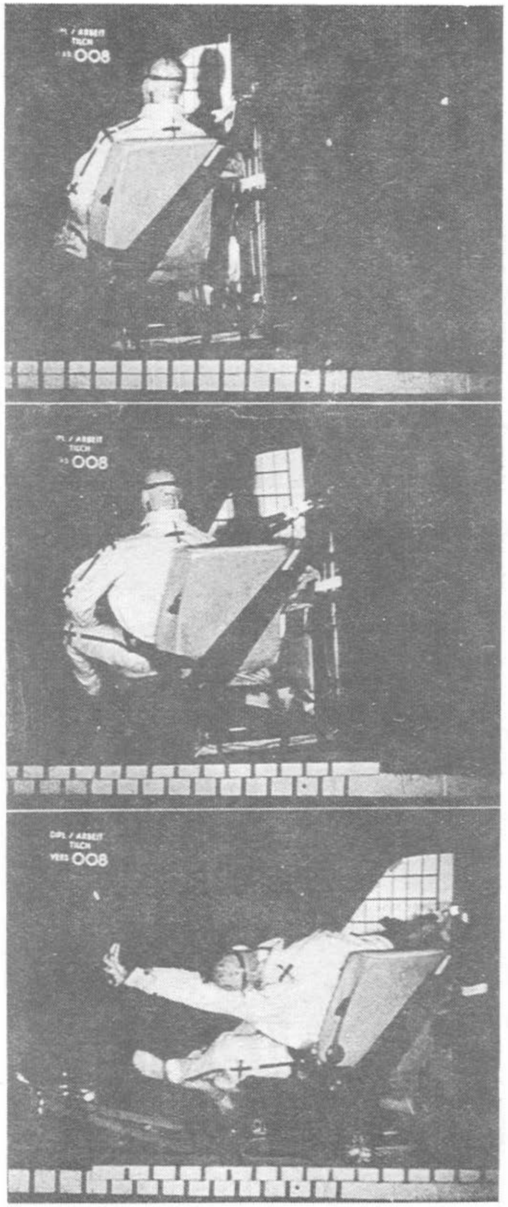

Fig. 10

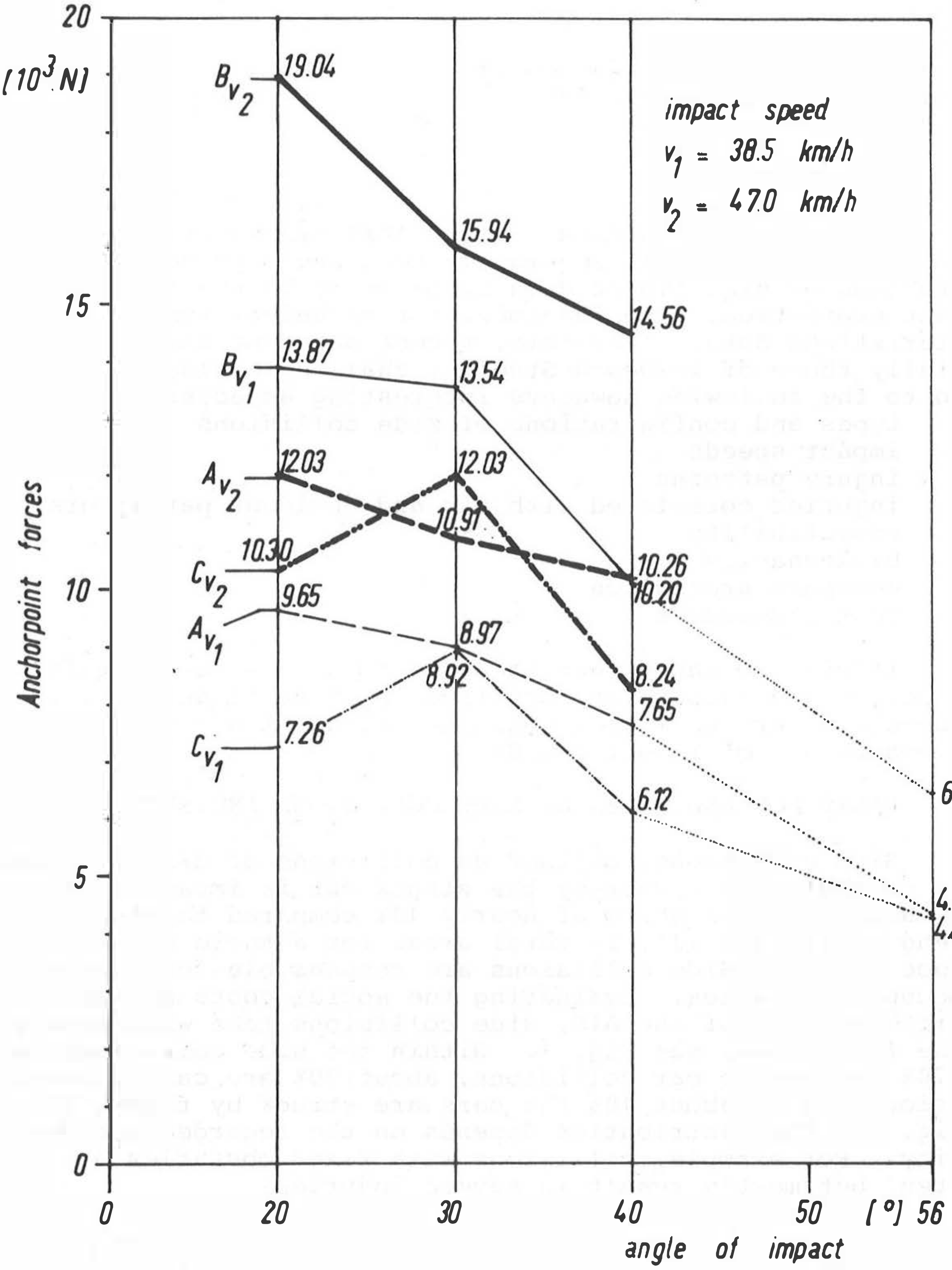

Fig. 9: Anchorpoint forces versus angle of impact during v_1(——) and v_2(▬▬) test runs